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(71) Applicant *(for all designated States except US)*: CHIRON SPA [IT/IT]; Via Fiorentina, 1, I-53100 Siena (IT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: GIULIANI, Marzia, Monica [IT/IT]; Via Fiorentina, 1, I-53100 Siena (IT). PIZZA, Mariagrazia [IT/IT]; Via Fiorentina, 1, I-53100 Siena (IT). RAPPUOLI, Rino [IT/IT]; Via Fiorentina, 1, I-53100 Siena (IT).

(74) Agents: HALLYBONE, Huw, George et al.; Carpmaels & Ransford, 43 Bloomsbury Square, London WC1A 2RA (GB).

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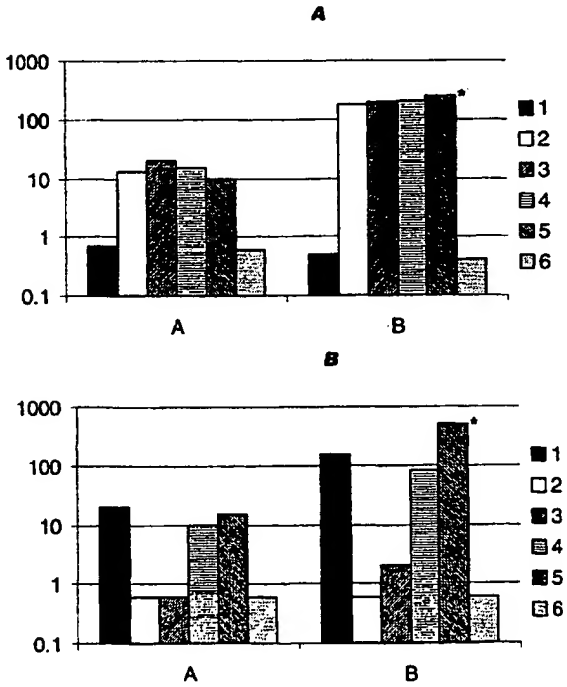
(54) Title: COMPOSITIONS COMPRISING *NEISSERIA MENINGITIDIS* ANTIGENS FROM SEROGROUPS B AND C



(57) Abstract: International patent application WO99/61053 discloses immunogenic compositions that comprise *N.meningitidis* serogroup C oligosaccharide conjugated to a carrier, in combination with *N.meningitidis* serogroup B outer membrane protein. These are disclosed in the present application in combination with further *Neisserial* proteins and/or protective antigens against other pathogenic organisms (*e.g. Haemophilus influenzae*, DTP, HBV, *etc.*).

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COMPOSITIONS COMPRISING *NEISSERIA MENINGITIDIS* ANTIGENS FROM SEROGROUPS B AND C

All documents cited herein are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

This invention is in the field of immunogenic compositions, more particularly those comprising combinations of immunogenic molecules from *Neisseria meningitidis* serogroups B and C (NmB and NmC).

BACKGROUND ART

Serogroup B and C strains of *Neisseria meningitidis* (Nm) together account for the majority of invasive diseases in Europe and the United States. Vaccines against individual Nm serogroups are presently available. The NmB vaccine from the Norwegian National Institute of Public Health is safe, elicits strain-specific immunity in children and adults, and is efficacious in preventing NmB disease in adolescents. This vaccine has typically been combined with meningococcal C polysaccharide vaccine and given with alum. The plain polysaccharide vaccine component, however, is not effective in infants and young children. The Chiron NmC conjugate (conj.) vaccine is also safe, elicits high titres of serum bactericidal antibody in infants vaccinated as young as two and three months of age, and induces immunologic B cell memory to the unconjugated NmC polysaccharide.

To provide a combination vaccine for NmB and NmC which induces an immune response to both serogroups, international patent application WO99/61053 discloses immunogenic compositions that comprise (a) NmC oligosaccharide conjugated to a carrier, in combination with (b) NmB outer membrane protein. The combination vaccine induces an immune response to both serogroups that is not significantly different from the immune response induced by each serogroup alone. It is an object of the present invention to develop these into compositions that induce immune responses against a wider variety of organisms.

DISCLOSURE OF THE INVENTION

Accordingly, the invention provides an immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) one or more of the following:

- the proteins disclosed in WO99/57280 or immunogenic fragments thereof;

- the proteins disclosed in WO99/36544 or immunogenic fragments thereof;
- the proteins disclosed in WO99/24578 or immunogenic fragments thereof;
- the proteins disclosed in WO97/28273 or immunogenic fragments thereof;
- the proteins disclosed in WO96/29412 or immunogenic fragments thereof;
- the proteins disclosed in WO95/03413 or immunogenic fragments thereof;
- the proteins disclosed in WO99/31132 or immunogenic fragments thereof;
- a protective antigen against *Neisseria meningitidis* serogroup A;
- a protective antigen against *Neisseria meningitidis* serogroup Y;
- a protective antigen against *Neisseria meningitidis* serogroup W;
- a protective antigen against *Haemophilus influenzae*;
- a protective antigen against *pneumococcus*;
- a protective antigen against diphtheria;
- a protective antigen against tetanus;
- a protective antigen against whooping cough;
- a protective antigen against *Helicobacter pylori*;
- a protective antigen against polio; and/or
- a protective antigen against hepatitis B virus.

As well as inducing an immune response to both *N.meningitidis* B and C, the immunogenic compositions of the invention can induce an immune response against further organisms.

Component (a)

The oligosaccharide of component (a) is preferably the Chiron oligosaccharide, representing NmC polysaccharide fragments of from preferably about 12 to about 22 repeating units.

The NmC oligosaccharide of component (a) is preferably conjugated to a carrier. The carrier is preferably a protein, but may alternatively be a polysaccharide, polylactic acid, polyglycolic acid, polymeric amino acids, amino acid co-polymer, lipid aggregate, or inactive virus particle.

More preferably, the carrier is a protein. Most preferably, the carrier is CRM197, a non-toxic diphtheria toxin. Each dose preferably has 10μg of oligosaccharide to 12.5-33μg CRM197 (*i.e.* to maintain a oligo/protein ratio of from about 0.3 to about 0.8). More preferably, about 20 μg of CRM197 can be used.

The dosage of NmC conjugate or polysaccharide is expressed in μg of sialic acid. An NmC vaccine containing unconjugated polysaccharide (referred to herein as "NmC polysaccharide" or "MenC Ps") can also be used. MenC Ps is a crude isolate comprising polysaccharides preferably from about 60 to about 80 repeating units.

For further details of NmC-CRM197 conjugation, see Costantino *et al.* (1992) *Vaccine* 10:691-698.

Component (b)

The NmB outer membrane protein of component (b) preferably comprises partially purified outer membrane proteins from strain 44/76 (B15:P1.7, 16:L3,7,9).

The outer membrane protein is preferably present as proteoliposomic vesicles, obtained for example as a result of the extraction process using deoxycholate.

The dosage of NmB is expressed in μg of protein. Preferably, the NmB immune composition/vaccine components can be obtained from the National Institute of Public Health of Norway. The NmB/alum vaccine comprises 0.05 mg/ml NmB protein, 3.33 mg/ml $Al(OH)_3$ (alum), and 0.10 mg/ml thiomersalsodium.

Component (c)

Preferably, component (c) comprises one or more of:

- a protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200, 202, 204, 206, 208, 210, 212, 214, 216, 218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254, 256, 258, 260, 262, 264, 266, 268, 270, 272, 274, 276, 278, 280, 282, 284, 286, 288, 290, 292, 294, 296, 298, 300, 302, 304, 306, 308, 310, 312, 314, 316, 318, 320, 322, 324, 326, 328, 330, 332, 334, 336, 338, 340, 342, 344, 346, 348, 350, 352, 354, 356, 358, 360, 362, 364, 366, 368, 370, 372, 374, 376, 378, 380, 382, 384, 386, 388, 390, 392, 394, 396, 398, 400, 402, 404, 406, 408, 410, 412, 414, 416, 418, 420, 422, 424, 426, 428, 430, 432, 434, 436, 438, 440, 442, 444, 446, 448, 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, 472, 474, 476, 478, 480, 482, 484, 486, 488, 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, 520, 522, 524,

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- a protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, & 90, as disclosed in WO99/36544 (or a protein comprising an immunogenic fragment of one or more of these SEQ IDs, or a protein comprising a sequence having sequence identity (preferably greater than 50% *eg.* 60%, 70%, 80%, 90%, 95%, 99% or more) to one of these SEQ IDs);
- a protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200, 202, 204, 206, 208, 210, 212, 214, 216, 218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254, 256, 258, 260, 262, 264, 266, 268, 270, 272, 274, 276, 278, 280, 282, 284, 286, 288, 290, 292, 294, 296, 298, 300, 302, 304, 306, 308, 310, 312, 314, 316, 318, 320, 322, 324, 326, 328, 330, 332, 334, 336, 338, 340, 342, 344, 346, 348, 350, 352, 354, 356, 358, 360, 362, 364, 366, 368, 370, 372, 374, 376, 378, 380, 382, 384, 386, 388, 390, 392, 394, 396, 398, 400, 402, 404, 406, 408, 410, 412, 414, 416, 418, 420, 422, 424, 426, 428, 430, 432, 434, 436, 438, 440, 442, 444, 446, 448, 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, 472, 474, 476, 478, 480, 482, 484, 486, 488, 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, 520, 522, 524,

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- The protein disclosed in Figure 4 or Figure 13 of WO97/28273;
- A protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 1-8 disclosed in WO96/29412 (or a protein comprising an immunogenic fragment of one or more of these SEQ IDs, or a protein comprising a sequence having sequence identity (preferably greater than 50% *eg.* 60%, 70%, 80%, 90%, 95%, 99% or more) to one of these SEQ IDs);
- A protein comprising an amino acid sequence selected from the group consisting of SEQ IDs 1-23 disclosed in WO95/03413 (or a protein comprising an immunogenic fragment of one or more of these SEQ IDs, or a protein comprising a sequence having sequence identity (preferably greater than 50% *eg.* 60%, 70%, 80%, 90%, 95%, 99% or more) to one of these SEQ IDs);
- A protein comprising an amino acid sequence consisting of SEQ ID 2 disclosed in WO99/31132 (or a protein comprising an immunogenic fragment of SEQ ID 2, or a protein comprising a sequence having sequence identity (preferably greater than 50% *eg.* 60%, 70%, 80%, 90%, 95%, 99% or more) to SEQ ID 2);

- A polysaccharide antigen against *Neisseria meningitidis* serogroup A;
- A polysaccharide antigen against *Neisseria meningitidis* serogroup Y;
- A polysaccharide antigen against *Neisseria meningitidis* serogroup W;
- A polysaccharide antigen against *Haemophilus influenzae*;
- A polysaccharide antigen against *pneumococcus*;
- A protective antigen against diphtheria, consisting of a diphtheria toxoid, such as the CRM197 mutant [*eg.* Del Guidice *et al.* (1998) *Molecular Aspects of Medicine* 19:1-70].
- A protective antigen against tetanus, consisting of a tetanus toxoid [*eg.* Wassilak & Orenstein, Chapter 4 of *Vaccines* (eds. Plotkin & Mortimer), 1988]
- A protective antigen against whooping cough, comprising pertussis holotoxin (PT) and filamentous haemagglutinin (FHA); optionally further comprising pertactin and/or agglutinogens 2 and 3 [*eg.* Gustafsson *et al.* (1996) *N. Engl. J. Med.* 334:349-355; Rappuoli *et al.* (1991) *TIBTECH* 9:232-238].
- A protective antigen against *H.pylori*, comprising one or more of CagA (*eg.* WO93/18150), VacA (*eg.* WO93/18150), NAP (*eg.* WO99/53310), HopX (*eg.* WO98/04702), HopY (*eg.* WO98/04702), urease.
- A protective antigen against hepatitis B virus, consisting of a HBV surface antigen and/or a HBV core antigen.

Where component (c) comprises an antigen against diphtheria, it preferably also comprises antigens against tetanus and polio. Where component (c) comprises an antigen against tetanus, it preferably also comprises antigens against diphtheria and polio. Where component (c) comprises an antigen against polio, it preferably also comprises antigens against diphtheria and tetanus.

Pertussis toxin is a toxic protein and, when present in component (c), it is preferably detoxified. Detoxification may be by chemical and/or genetic means. A preferred detoxified mutant is the 9K/129G double mutant [*eg.* Rappuoli (1997) *Nature Medicine* 3:374-376].

Where component (c) includes a protein that exists in different nascent and mature forms, the mature form of the protein is preferably used. For example, where NspA is included, (WO96/29412; see also Martin *et al.* (1997) *J. Exp. Med* 185 1173-1183) the mature form of the protein lacking the signal peptide is preferably used.

Where component (c) includes a polysaccharide antigen, the polysaccharide is preferably conjugated to a carrier protein.

Component (c) preferably should not diminish the immune responses raised in response to components (a) and (b).

Pharmaceutically acceptable carrier

The compositions of the invention may also comprise a pharmaceutically acceptable carrier.

The carrier can be organic, inorganic, or both. Suitable carriers well known to those of skill in the art and include, without limitation, large, slowly metabolized macromolecules such as proteins, polysaccharides, polylactic acids, polyglycolic acids, polymeric amino acids, amino acid copolymers, lipid aggregates (such as oil droplets or liposomes) and inactive virus particles. Pharmaceutically acceptable salts can be used therein, for example, mineral acid salts such as hydrochlorides, hydrobromides, phosphates, sulfates, and the like; and the salts of organic acids such as acetates, propionates, malonates, benzoates, and the like. A thorough discussion of pharmaceutically acceptable excipients is available in Remington's Pharmaceutical Sciences (Mack Pub. Co., N.J. 1991). Pharmaceutically acceptable carriers in compositions may contain liquids such as water, saline, glycerol and ethanol. Additionally, auxiliary substances, such as wetting or emulsifying agents, pH buffering substances, and the like, may be present in such vehicles. Typically, the therapeutic compositions are prepared as injectables, either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid vehicles prior to injection may also be prepared. Liposomes are included within the definition of a pharmaceutically acceptable carrier.

The carrier can also function as an immunostimulatory agent *e.g.* an adjuvant. Suitable adjuvants are well known to those of skill in the art.

Preferred carriers are aluminum hydroxide (alum) and MF59.

Alum can be obtained from Superfos, Bedbaek, Denmark, and is a 3% solution. When present, ~1 mg to ~1.67 mg of alum is used per dose.

Where component (c) includes a hepatitis B antigen, aluminium hydroxide is preferably not used as a carrier (*e.g.* EP-A-0642355). Similarly, where component (c) includes a *H.influenzae* polysaccharide conjugate, aluminium hydroxide is preferably not used as a carrier (*e.g.* EP-A-0833662). Aluminium phosphate may be used instead.

MF59 is a micro-fluidized emulsion of squalene in water that has been shown to be safe and to augment serum antibody responses to a variety of vaccines. MF59 comprises about 5% squalene, 0.5% Tween 80 and about 0.5% Span 85. The adjuvant MF59 is described in WO 90/14837. MF59 can be made according to the procedures described in, for example, Ott *et al.* in *Vaccine Design: The Subunit And Adjuvant Approach* (1995, Powell and Newman, Eds., Plenum Press, New York, p. 277-296); Singh *et al.* (1998) *Vaccine* 16, 1822-1827; Ott *et al.* (1995) *Vaccine* 13, 1557-1562; Valensi *et al.* (1994) *J. Immunol.* 153, 4029-39.

Other carrier-adjuvants that may be used include oil-in-water emulsion formulations (with or without other specific immunostimulating agents such as muramyl peptides or bacterial cell wall components), such as for example (a) MF59 as described above (optionally containing various amounts of MTP-PE although not required) (b) SAF, containing 10% Squalane, 0.4% Tween 80, 5% pluronic-blocked polymer L121, and thr-MDP (see below) either microfluidized into a submicron emulsion or vortexed to generate a larger particle size emulsion, and (c) Ribi™ adjuvant system (RAS), (Ribi Immunochem, Hamilton, MT) containing 2% Squalene, 0.2% Tween 80, and one or more bacterial cell wall components from the group consisting of monophosphorylipid A (MPL), trehalose dimycolate (TDM), and cell wall skeleton (CWS), preferably MPL + CWS (Detox™); (3) saponin adjuvants, such as Stimulon™ (Cambridge Bioscience, Worcester, MA) may be used or particles generated therefrom such as ISCOMs (immunostimulating complexes); (4) Complete Freund's Adjuvant (CFA) and Incomplete Freund's Adjuvant (IFA); (5) cytokines, such as interleukins (*eg.* IL-1, IL-2, IL-4, IL-5, IL-6, IL-7, IL-12, *etc.*), interferons (*eg.* gamma interferon), macrophage colony stimulating factor (M-CSF), tumor necrosis factor (TNF), etc; and (6) other substances that act as immunostimulating agents to enhance the effectiveness of the composition.

As mentioned above, muramyl peptides include, but are not limited to, N-acetyl-muramyl-L-threonyl-D-isoglutamine (thr-MDP), N-acetyl-normuramyl-L-alanyl-D-isoglutamine (nor-MDP), N-acetylmuramyl-L-alanyl-D-isoglutaminyl-L-alanine-2-(1'-2'-dipalmitoyl-*sn*-glycero-3-hydroxyphosphoryloxy)-ethylamine (MTP-PE), *etc.*

Immunogenicity

As used herein, the term "immunogenic" refers to material which induces the production of antibody upon administration to a vertebrate, including humans.

The compositions of the invention will typically employ an immunologically effective amount of components (a), (b) and (c). That is, there will be included an amount of component (a), (b) or (c) which, in combination with any adjuvant present, will cause the subject to produce a specific and sufficient immunological response, preferably a T or B lymphocyte response, so as to impart protection to the subject from subsequent exposure to *Neisseria*.

An "immunologically effective amount," is effective, either in a single dose or as part of a series, for inducing the production of antibody for either the treatment or prevention of disease. This amount will vary depending upon a variety of factors, including the physical condition of the subject, and can be readily determined by someone of skill in the art.

No single dose designation can be assigned which will provide specific guidance for each and every antigen which can be employed in this invention. The effective amount of antigen will be a function of its inherent activity and purity and is empirically determined by those of ordinary skill in the art via routine experimentation.

The immunogenic compositions according to the present invention will typically comprise an immunostimulatory amount of *Neisseria* antigen. An immunostimulatory amount is that amount which is sufficient to induce a measurable humoral or cellular immune response. For example, the immunogenic compositions of the present invention comprise about 1 nanogram to about 1000 micrograms of antigen or about 10 nanograms to about 800 micrograms of antigen. In some preferred embodiments, the immunogenic compositions contain about 0.1 to about 500 micrograms of antigen. In some preferred embodiments, the immunogenic compositions contain about 1 to about 350 micrograms of antigen. In some preferred embodiments, the immunogenic compositions contain about 25 to about 250 micrograms of antigen. In some preferred embodiments, the immunogenic compositions contain about 100 micrograms of antigen. One skilled in the art can readily formulate an immunogenic composition comprising any desired amount of antigen, which can be empirically determined by those of ordinary skill in the art via routine experimentation. The immunogenic compositions can be conveniently administered in unit dosage form and can be prepared by any of the methods well known in the pharmaceutical art, for example, as described in Remington's Pharmaceutical Sciences (Mack Pub. Co., Easton, PA, 1980)

Vaccines

The present invention is also directed to vaccines comprising any of the immunogenic compositions described above.

As used herein, the term "vaccine" means an immunogenic composition which is able to induce a microbicidal immune response. Preferably, the vaccines of the present invention elicit a bactericidal antibody response.

Vaccines according to the invention may either be prophylactic (*ie.* to prevent infection) or therapeutic (*ie.* to treat disease after infection).

The invention also provides a method of inducing an immune response at least to NmB and NmC, or vaccinating, comprising administering an immunologically effective amount of an immunogenic composition of the invention. Administration can be to a human , and may be by any mode known to those skilled in the art, including by parenteral, rectal, intraperitoneal, intramuscular, or subcutaneous routes. Direct delivery will generally be accomplished by injection, either subcutaneously, intraperitoneally, intravenously or intramuscularly or delivered to the interstitial space of a tissue. The compositions can also be administered into a lesion. Other modes of administration include oral and pulmonary administration, suppositories, and transdermal or transcutaneous applications (*eg.* WO98/20734), needles, and gene guns or hyposprays. Dosage treatment may be a single dose schedule or a multiple dose schedule.

The invention also provides the compositions of the invention for use as medicaments. It further provides the use of a composition of the invention in the manufacture of a medicament for treating or preventing infection due to Neisserial bacteria.

As an alternative to protein-based vaccines, nucleic acid vaccination may be employed [*eg.* Robinson & Torres (1997) *Seminars in Immunology* 9:271-283; Donnelly *et al.* (1997) *Annu Rev Immunol* 15:617-648]. One or more protein components of the compositions of the invention may thus be replaced by nucleic acid (preferably DNA) that encodes the protein.

Manufacturing process

The invention provides a process for the manufacture of a composition according to the invention, comprising mixing components (a), (b) and (c).

General

The practice of the present invention will employ, unless otherwise indicated, conventional techniques of molecular biology, microbiology, recombinant DNA, and immunology, which are within the skill of the art. Such techniques are explained fully in the literature *eg.* Sambrook *Molecular Cloning; A Laboratory Manual, Second Edition* (1989); *DNA Cloning, Volumes I and ii* (D.N Glover ed. 1985); *Oligonucleotide Synthesis* (M.J. Gait ed, 1984); *Nucleic Acid Hybridization* (B.D. Hames & S.J. Higgins eds. 1984); *Transcription and Translation* (B.D. Hames & S.J. Higgins eds. 1984); *Animal Cell Culture* (R.I. Freshney ed. 1986); *Immobilized Cells and Enzymes* (IRL Press, 1986); B. Perbal, *A Practical Guide to Molecular Cloning* (1984); the *Methods in Enzymology* series (Academic Press, Inc.), especially volumes 154 & 155; *Gene Transfer Vectors for Mammalian Cells* (J.H. Miller and M.P. Calos eds. 1987, Cold Spring Harbor Laboratory); Mayer and Walker, eds. (1987), *Immunochemical Methods in Cell and Molecular Biology* (Academic Press, London); Scopes, (1987) *Protein Purification: Principles and Practice*, Second Edition (Springer-Verlag, N.Y.), and *Handbook of Experimental Immunology, Volumes I-IV* (D.M. Weir and C. C. Blackwell eds 1986).

Definitions

Standard abbreviations for nucleotides and amino acids are used in this specification.

The term "comprising" means "including" as well as "consisting" *eg.* a composition "comprising" X may consist exclusively of X or may include something additional to X, such as X+Y.

Identity between proteins is preferably determined by the Smith-Waterman homology search algorithm as implemented in the MPSRCH program (Oxford Molecular), using an affine gap search with parameters gap open penalty=12 and gap extension penalty=1.

BRIEF DESCRIPTION OF DRAWINGS

In all figures, Group A is data at 28 days post 1, and Group B is data at 18 days post 2.

Figure 1 shows the geometric mean IgG antibody titres (KU/ml) against (1A) NmB OMV and (1B) NmC capsule, as determined by ELISA. The * indicates (1A) $P \leq 0.03$ for group 5 *vs.* groups 2 & 3, (1B) $P \leq 0.02$ for group 5 *vs.* groups 1 & 4.

Figure 2 shows the titres of serum bactericidal antibody (1/geometric mean titre) to (2A) NmB and (2B) NmC. The * indicates $P \leq 0.003$ for group 5 *vs.* group 2.

MODES FOR CARRYING OUT THE INVENTION

The invention is further illustrated by way of the following examples which are intended to elucidate the invention. The foregoing examples are meant to illustrate the invention and are not to be construed to limit the invention in any way. Those skilled in the art will recognise modifications that are within the spirit and scope of the invention.

Example 1: ELISA results

Groups of guinea pigs (n=15 animals) received one of the vaccines set forth in Table 1:

Table 1

Group	Components	Amount per dose
Group 1	NmC conj./alum	10 µg /1 mg
Group 2	NmB/alum	25 µg/1 mg
Group 3	NmC polysaccharide/NmB/alum	10 µg /25 µg /1 mg
Group 4	NmC conj./NmB/alum	10 µg/25 µg/1 mg
Group 5	NmC conj./NmB/MF59	10 µg /25 µg /0.5 ml.
Group 6 (n=5) comprised control animals that received alum alone.		

Eighty guinea pigs were randomised into the groups set forth above and received one of six vaccine combinations. For the data presented in Table 2, each animal received two injections, IM, separated by 28 days. Serum samples were obtained prior to each injection, and 18 days after the second injection. For the data presented in Figures 1A and 1B, each animal received two immunisations separated by six weeks. Each dose consisted of two 0.25 ml IM injections. Serum samples were obtained immediately prior to each injection, and 14 or 18 days after the second injection.

Serum samples were assayed for IgG anticapsular antibody concentrations to NmC (Table 2 and Fig.1A) and for IgG anti-outer membrane vesicle (OMV) antibody concentrations to NmB by ELISA (Fig.1B). The ELISA data were generated in a representative assay of individual animal sera (Table 2) and also expressed as averages from a plurality of assays (Figs. 1A & 1B). The summary ELISA data in Table 2 are, therefore, expressed as geometric means.

For the ELISA, MCPS-ADH (NmC polysaccharide-adipic acid dihydrazide) conjugate or OMV components was coated onto polystyrene microtiter plates overnight at 4°C, 1 µg/ml, 100 µl/well. On each coated plate, 100 µl/well of each of a reference standard (i.e., pooled guinea

pig serum), a positive control, a negative control, and the serum samples were two-fold serially diluted in a buffer containing 75 µM ammonium thiocyanate, and incubated for two hours at room temperature. Rabbit anti-guinea pig IgG antibody conjugated to peroxidase was added to the wells (100 µl/well). After 2 hours, the colorimetric substrate 3,3',5,5', Tetramethylbenzidine (TMB) (100 µl/well) was added, and the color was developed for 15 minutes. The levels of antibodies to MCPS and to OMV present in the controls and samples were obtained from a standard curve using the reference standard which has an assigned value of 100 ELISA units/ml. The results are shown in Table 2 and Figures 1A and 1B.

The results summarised in Table 2 and Figures 1A and 1B reveal that the combination vaccine was immunogenic, as measured by NmB and NmC IgG antibody titers, respectively.

Table 2: IgG NmC Antibody Responses (GMT)

		SCN Assay	
Vaccine	**Adjuvant**	**Post-1**	**Post-2**
NmC Conj.	Alum	20.3	155
MenB	Alum	<1	<1
NmC Ps + MenB	Alum	<1	1.5
NmC Conj. + MenB	Alum	9.5	71
NmC Conj. + MenB	MF59	15.2	426
None	Alum	<1	<1

Figure 1A shows that a specific anti-meningococcal B antibody response was induced by the vaccine combinations comprising NmB. Figure 1B shows that a specific anti-meningococcal C antibody response was induced by the vaccine combinations comprising NmC. In particular, the antibody response induced by the combination of the NmC conjugate and NmB in the presence of MF59 adjuvant (Group 5) was significantly greater than the antibody response induced by either the NmC conjugate alone (Group 1) or the combination of the NmC conjugate and NmB in the presence of alum (Group 4). When the adjuvant MF59 was present, the antibody titre for the combination vaccine increased approximately six-fold.

Example 2: Bactericidal Titres

Serum samples were tested for complement-mediated bactericidal titres to MenC strain 60E and MenB strain 44/76. Bactericidal titres were assayed on pooled sera from each group. Bactericidal data were generated using human complement.

Components of the assay (*i.e.* buffer, antibody, complement, and bacteria) were added to sterile, 96-well tissue culture plates with lids (Nunc # 167008). The plates were maintained at room temperature during the assay. To each well, 50 µl Gey's buffer (Gibco) containing 1% RIA Grade BSA (Sigma), 25 µl of the diluted test antibody, 25 µl of bacteria diluted 1:8000 in Gey's buffer/1% BSA, were sequentially added. Control wells include 1) Gey's buffer/1% BSA and bacteria alone (to determine if the organisms are viable in the diluent alone); 2) a time 0 control containing 75 µl buffer, 25 µl heat-inactivated (56°C, 30 min.) human complement, and 25 µl bacteria; and 3) a toxicity control testing the complement at 20% and 40% with buffer and bacteria to verify that the complement source is non-toxic to the test strain. All antibody samples (at the highest concentration assayed) were also tested with heat-inactivated complement to show that a decrease in colony forming units (cfu) in the presence of antibody is complement dependent. After all reagents were added, 22µl was taken from each control well and plated onto Mueller-Hinton agar plates by allowing the sample to run from the top to the bottom of the plate, to determine the cfu in the well at 0 min. The microtitre plates were then covered and sealed with parafilm, and rotated gently for 1 hour at 37°C in a 4% CO_2 incubator. The plates were then removed, and a 22 µl sample from each well plated on Mueller-Hinton agar. The culture plates were incubated for about 18 hours at 37°C, with 4% CO_2. The colonies were counted, and % survival determined for each test well: % survival = ([cfu of sample well at 60 min]/[cfu in the heat inactivated complement control well at time 0 min.]) x 100. Bactericidal titres reported are those which resulted in 50% survival. Results from a single experiment are presented in Table 3. Results are also presented in Figures 2A and 2B, with Figure 2B representing average titres from a plurality of experiments.

As the results summarized in Table 3 reveal, the combination vaccine elicited high titers of serum bactericidal antibody for both NmB and NmC. Bactericidal NmC antibody titer was slightly higher for the combination vaccine using MF59 as the carrier, but there was essentially no effect on bactericidal NmB titer using MF59. Interestingly, two- to five-fold higher NmB bactericidal titers were obtained with the combination vaccine than with the NmB vaccine alone. Figure 2A demonstrates that the antibodies directed to meningococcal B induced by the vaccine combinations comprising NmB were bactericidal. Figure 2B demonstrates that the antibodies directed to meningococcal C induced by the vaccine combinations comprising NmC conjugate were also bactericidal.

Table 3

	NmC (1/titer)			NmB (1/titer)		
Group Vaccine	**Pre**	**Post-1**	**Post-2**	**Pre**	**Post-1**	**Post-2**
NmC conj. + Alum	<5	80	>3375	<5	<5	<5
NmB + Alum	<5	<5	15	<5	15	800
NmC Ps + NmB + Alum	<5	<5	30	<5	25	1500
NmC Conj. + NmB + Alum	<5	25	2000	<5	25	5000
NmC Conj. + NmB + MF59	<5	50	>3375	<5	25	4000
Alum	<5	<5	<5	<5	<5	<5

Example 3: Comparison of Alum and MF59 Adjuvants

Serum from the animals described above in Figures 1A and 1B were compared and MenC and MenB antibody responses generated by NmB/NmC conj. in either alum or MF59 adjuvant were detected as described above in Examples 1 and 2. The results are shown in Table 4:

Table 4 Ratios of antibody responses of animals given combination of NmB OMVs + NmC conjugate, with either $Al(OH)_3$ or MF59 adjuvant

	Ratio of GMT MF59 : GMT $Al(OH)_3$	
Assay	*28 days, post-1*	*18 days, post-2*
NmC		
IgG	1.6	6.0 **
Bactericidal	1.0	1.2 *
NmB		
IgG	0.7	1.4
Bactericidal	0.9	1.4

* pooled sera only tested

** $p \leq 0.001$

These data demonstrate that the antibody response to meningococcus C was approximately 6-fold greater in vaccines comprising MF59 adjuvant.

Example 4: Comparison of Responses Generated by Combination* vs. *Monovalent Vaccines

Serum from the animals described above in Figures 1A and 1B were compared and MenC and MenB antibody responses generated by NmB/NmC conj. were compared with the antibody responses generated by either the NmB vaccine alone or the NmC conj. alone in alum as described above in Examples 1 and 2. The results are shown in Table 5:

Table 5 Ratios of antibody responses of animals given combination / $Al(OH)_3$ *vs.* monovalent / $Al(OH)_3$		
	Ratio of GMT combo : GMT mono	
Assay	*28 days, post-1*	*18 days, post-2*
NmC		
IgG	0.5	0.5
Bactericidal	0.2 *	0.7 *
NmB		
IgG	1.3	1.2
Bactericidal	1.6	2.9 **

* pooled sera only tested
** $p \leq 0.05$

These data demonstrate that there is no significant difference in the antibody responses to the components of the NmB/NmC conj. vaccine compared to the responses induced by the respective monovalent vaccines (either NmB or NmC conj.).

Example 5: Addition of further antigens

The NmB/NmC combination is further augmented by adding antigens against other pathogenic organisms (*e.g.* NspA, HBsAg). Good immune responses are observed against NmB/NmC and against the additional antigens.

Example 6: Mixtures of NmB and NmC antigens

A trivalent mixture of strain 2996 MenB proteins '919' (*e.g.* WO99/57280 Figure 23 and SEQ IDs 3069-3074 therein), '287' (*e.g.* Figure 21 of WO99/57280; also SEQ IDs 3103-3108 therein) and 'ORF1' (*e.g.* example 77 of WO99/24578; see also WO99/55873) was used to immunise mice. The experiment was repeated with the addition of NmC conjugate. Aluminium hydroxide was used as adjuvant.

Titres measured in a bactericidal assay against the homologous strain and also heterologous MenB strains were as follows:

	2996	**BZ133**	**BZ232**	**1000**	**MC58**	**NGH38**
Trivalent	2048	2048	4	<4	64	4
+ NmC	2048	>32000	4	128	1024	128

It will be understood that this application describes the invention by way of example only and modifications may be made whilst remaining within the scope and spirit of the invention.

CLAIMS

1. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO99/57280 or an immunogenic fragment thereof.

2. The immunogenic composition of claim 1, wherein component (c) comprises one or more amino acid sequences selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200, 202, 204, 206, 208, 210, 212, 214, 216, 218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254, 256, 258, 260, 262, 264, 266, 268, 270, 272, 274, 276, 278, 280, 282, 284, 286, 288, 290, 292, 294, 296, 298, 300, 302, 304, 306, 308, 310, 312, 314, 316, 318, 320, 322, 324, 326, 328, 330, 332, 334, 336, 338, 340, 342, 344, 346, 348, 350, 352, 354, 356, 358, 360, 362, 364, 366, 368, 370, 372, 374, 376, 378, 380, 382, 384, 386, 388, 390, 392, 394, 396, 398, 400, 402, 404, 406, 408, 410, 412, 414, 416, 418, 420, 422, 424, 426, 428, 430, 432, 434, 436, 438, 440, 442, 444, 446, 448, 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, 472, 474, 476, 478, 480, 482, 484, 486, 488, 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, 520, 522, 524, 526, 528, 530, 532, 534, 536, 538, 540, 542, 544, 546, 548, 550, 552, 554, 556, 558, 560, 562, 564, 566, 568, 570, 572, 574, 576, 578, 580, 582, 584, 586, 588, 590, 592, 594, 596, 598, 600, 602, 604, 606, 608, 610, 612, 614, 616, 618, 620, 622, 624, 626, 628, 630, 632, 634, 636, 638, 640, 642, 644, 646, 648, 650, 652, 654, 656, 658, 660, 662, 664, 666, 668, 670, 672, 674, 676, 678, 680, 682, 684, 686, 688, 690, 692, 694, 696, 698, 700, 702, 704, 706, 708, 710, 712, 714, 716, 718, 720, 722, 724, 726, 728, 730, 732, 734, 736, 738, 740, 742, 744, 746, 748, 750, 752, 754, 756, 758, 760, 762, 764, 766, 768, 770, 772, 774, 776, 778, 780, 782, 784, 786, 788, 790, 792, 794, 796, 798, 800, 802, 804, 806, 808, 810, 812, 814, 816, 818, 820, 822, 824, 826, 828, 830, 832, 834, 836, 838, 840, 842, 844, 846, 848, 850, 852, 854, 856, 858, 860, 862, 864, 866, 868, 870, 872, 874, 876, 878, 880, 882, 884, 886, 888, 890, 892, 894, 896, 898, 900, 902, 904, 906, 908, 910, 912, 914, 916, 918, 920, 922, 924, 926, 928, 930, 932, 934, 936, 938, 940, 942, 944, 946, 948, 950, 952, 954, 956, 958, 960, 962, 964, 966, 968, 970, 972, 974, 976, 978, 980, 982, 984, 986, 988, 990, 992, 994, 996, 998, 1000, 1002, 1004, 1006, 1008, 1010, 1012, 1014, 1016, 1018, 1020, 1022, 1024, 1026, 1028, 1030, 1032, 1034, 1036, 1038, 1040, 1042, 1044, 1046, 1048, 1050, 1052, 1054, 1056, 1058, 1060, 1062, 1064, 1066, 1068, 1070, 1072, 1074, 1076, 1078, 1080, 1082, 1084, 1086, 1088, 1090, 1092, 1094, 1096, 1098, 1100, 1102, 1104, 1106, 1108, 1110, 1112, 1114, 1116, 1118, 1120, 1122, 1124, 1126, 1128, 1130, 1132, 1134, 1136, 1138, 1140, 1142, 1144, 1146, 1148, 1150, 1152, 1154, 1156, 1158, 1160, 1162, 1164, 1166, 1168, 1170, 1172, 1174, 1176, 1178, 1180, 1182, 1184, 1186, 1188, 1190, 1192, 1194, 1196, 1198, 1200, 1202, 1204, 1206, 1208, 1210, 1212, 1214, 1216, 1218, 1220, 1222, 1224, 1226,

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3. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO99/36544 or an immunogenic fragment thereof.

4. The immunogenic composition of claim 3, wherein component (c) comprises one or more amino acid sequences selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, & 90, as disclosed in WO99/36544.

5. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO99/24578 or an immunogenic fragment thereof.

6. The immunogenic composition of claim 5, wherein component (c) comprises one or more amino acid sequences selected from the group consisting of SEQ IDs 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200, 202, 204, 206, 208, 210, 212, 214, 216, 218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254, 256, 258, 260, 262, 264, 266, 268, 270, 272, 274, 276, 278, 280, 282, 284, 286, 288, 290, 292, 294, 296, 298, 300, 302, 304, 306, 308, 310, 312, 314, 316, 318, 320, 322, 324,

326, 328, 330, 332, 334, 336, 338, 340, 342, 344, 346, 348, 350, 352, 354, 356, 358, 360, 362, 364, 366, 368, 370, 372, 374, 376, 378, 380, 382, 384, 386, 388, 390, 392, 394, 396, 398, 400, 402, 404, 406, 408, 410, 412, 414, 416, 418, 420, 422, 424, 426, 428, 430, 432, 434, 436, 438, 440, 442, 444, 446, 448, 450, 452, 454, 456, 458, 460, 462, 464, 466, 468, 470, 472, 474, 476, 478, 480, 482, 484, 486, 488, 490, 492, 494, 496, 498, 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, 520, 522, 524, 526, 528, 530, 532, 534, 536, 538, 540, 542, 544, 546, 548, 550, 552, 554, 556, 558, 560, 562, 564, 566, 568, 570, 572, 574, 576, 578, 580, 582, 584, 586, 588, 590, 592, 594, 596, 598, 600, 602, 604, 606, 608, 610, 612, 614, 616, 618, 620, 622, 624, 626, 628, 630, 632, 634, 636, 638, 640, 642, 644, 646, 648, 650, 652, 654, 656, 658, 660, 662, 664, 666, 668, 670, 672, 674, 676, 678, 680, 682, 684, 686, 688, 690, 692, 694, 696, 698, 700, 702, 704, 706, 708, 710, 712, 714, 716, 718, 720, 722, 724, 726, 728, 730, 732, 734, 736, 738, 740, 742, 744, 746, 748, 750, 752, 754, 756, 758, 760, 762, 764, 766, 768, 770, 772, 774, 776, 778, 780, 782, 784, 786, 788, 790, 792, 794, 796, 798, 800, 802, 804, 806, 808, 810, 812, 814, 816, 818, 820, 822, 824, 826, 828, 830, 832, 834, 836, 838, 840, 842, 844, 846, 848, 850, 852, 854, 856, 858, 860, 862, 864, 866, 868, 870, 872, 874, 876, 878, 880, 882, 884, 886, 888, 890, & 892, as disclosed in WO99/24578.

7. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO97/28273 or an immunogenic fragment thereof.

8. The immunogenic composition of claim 7, wherein component (c) comprises the protein disclosed in Figure 4 or Figure 13 of WO97/28273.

9. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO96/29412 or an immunogenic fragment thereof.

10. The immunogenic composition of claim 9, wherein component (c) comprises an amino acid sequence selected from the group consisting of SEQ IDs 1-8 disclosed in WO96/29412.

11. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO95/03413 or an immunogenic fragment thereof.

12. The immunogenic composition of claim 11, wherein component (c) comprises an amino acid sequence selected from the group consisting of SEQ IDs 1-23 disclosed in WO95/03413.

13. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protein disclosed in WO99/31132 or an immunogenic fragment thereof.

14. The immunogenic composition of claim 13, wherein component (c) comprises an amino acid sequence consisting of SEQ ID 2 disclosed in WO99/31132.

15. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *Neisseria meningitidis* serogroup A.

16. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *Neisseria meningitidis* serogroup W.

17. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *Neisseria meningitidis* serogroup Y.

18. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *Haemophilus influenzae*.

19. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *pneumococcus*.

20. The immunogenic composition of claim 15, 16, 17, 18 or 19, wherein component (c) is a polysaccharide antigen.

21. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against diphtheria.

22. The immunogenic composition of claim 21, wherein component (c) is a diphtheria toxoid

23. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against tetanus.

24. The immunogenic composition of claim 23, wherein component (c) is a tetanus toxoid

25. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against whooping cough.

26. The immunogenic composition of claim 25, wherein component (c) comprises comprising pertussis holotoxin (PT) and filamentous haemagglutinin (FHA), optionally further comprising pertactin and/or agglutinogens 2 and 3

27. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against hepatitis B virus.

28. The immunogenic composition of claim 27, wherein component (c) is a HBV surface antigen and/or a HBV core antigen.

29. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *Helicobacter pylori*.

30. The immunogenic composition of claim 28, wherein component (c) comprises CagA, VacA, NAP, HopX, HopY and/or, urease.

31. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB outer membrane protein, *characterised in that* the composition also comprises (c) a protective antigen against *Neisseria meningitidis* serogroup A, a protective antigen against *Neisseria meningitidis* serogroup W, a protective antigen against *Neisseria meningitidis* serogroup Y, a protective antigen against *Haemophilus influenzae*, a protective antigen against *pneumococcus*, a protective antigen against diphtheria, a protective antigen against tetanus, a protective antigen against whooping cough, a protective antigen against hepatitis B virus, and/or a protective antigen against *Helicobacter pylori*.

32. An immunogenic composition according to any preceding claim, wherein the NmB outer membrane proteins are preferably present as proteoliposomic vesicles.

33. An immunogenic composition comprising (a) NmC oligosaccharide and (b) NmB proteins 919, 287 and/or ORF1.

34. An immunogenic composition according to any preceding claim, wherein the NmC oligosaccharide is conjugated to a carrier.

35. The immunogenic composition of claim 34, wherein the carrier is a protein.

36. The immunogenic composition of claim 35, wherein the carrier is CRM197.

37. An immunogenic composition according to any preceding claim, further comprising a carrier selected from aluminium hydroxide or MF59.

38. A vaccine comprising an immunogenic composition according to any preceding claim.

FIGURE 1A

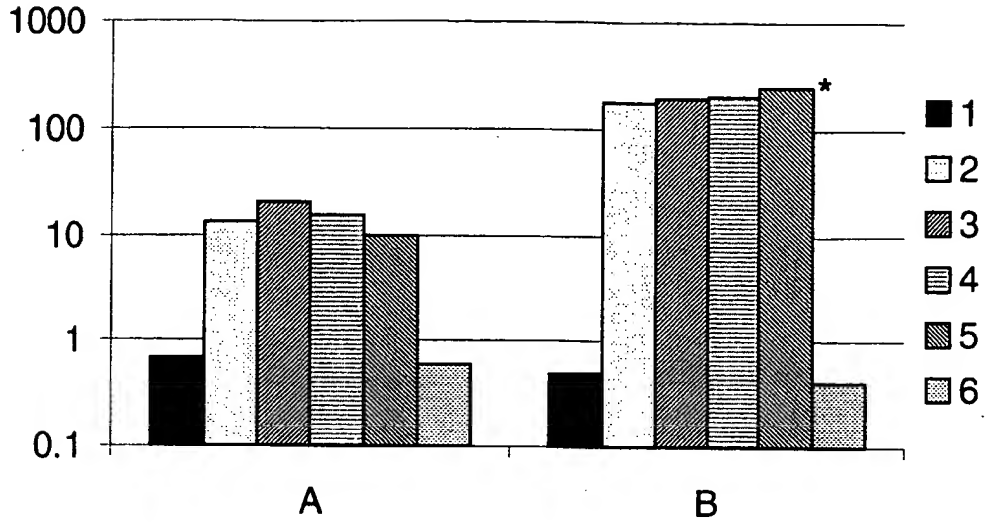

FIGURE 1B

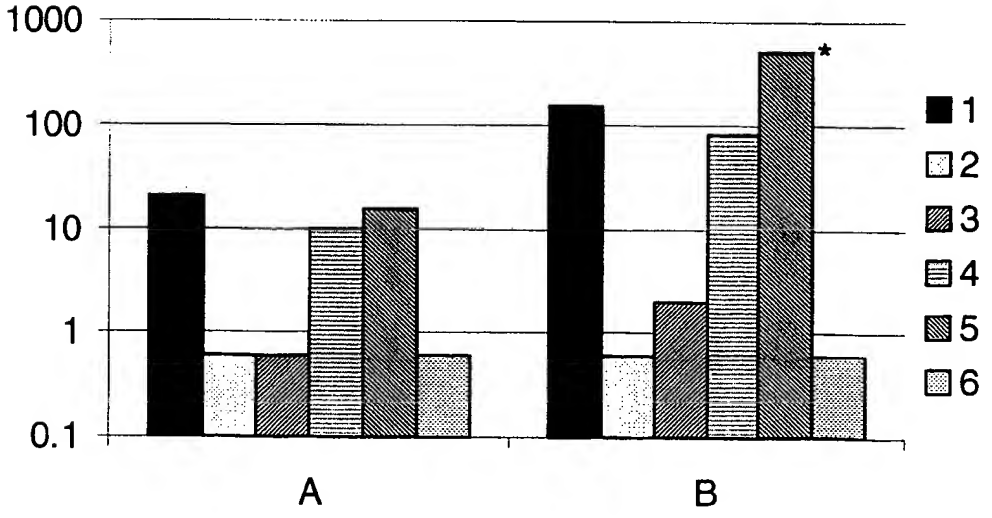

FIGURE 2A

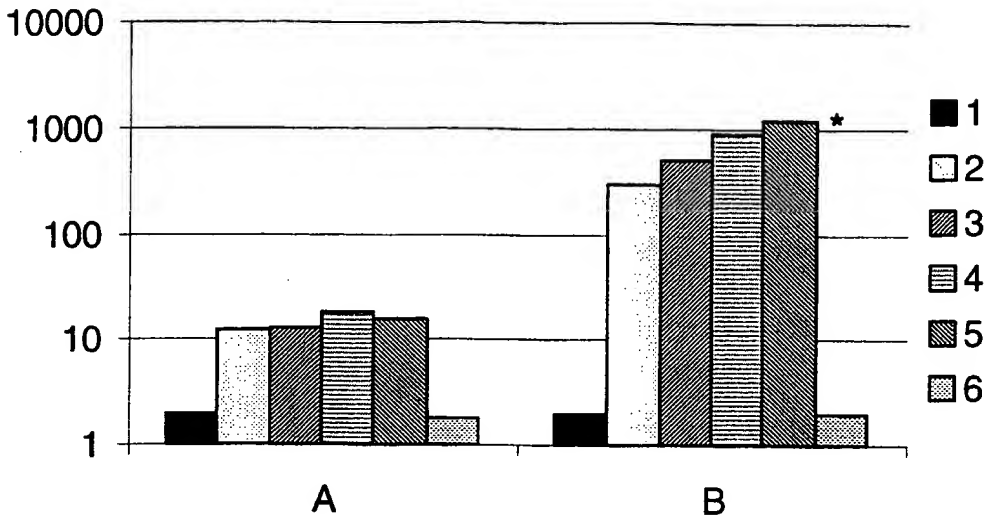

FIGURE 2B